# HISTORY OF THE DEVELOPMENT OF MEDICAL INFORMATION*

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ONE of the educational objectives of this conference is to review and demonstrate the ways in which medical information has been developed and used throughout history. My topic this morning was defined by the conference planning committee to provide a general historical background about the development of medical information and to set the stage, so to speak, for the other papers which will be presented.

Included among the aphorisms of Sir William Osler is the following admonition: "When you have made and recorded the unusual or original observation, or when you have accomplished a piece of research in laboratory or ward, do not be satisfied with a verbal communication at a medical society. Publish it."[1] Implicit in Osler's advice are the concepts of information and communication and the value of each to medical knowledge.

The *Oxford English Dictionary* defines information as the communication of instructive knowledge. This is a rather restrictive definition because it implies that that which is not knowledge or instructive knowledge is not information. The rather formidable sales volume of some of today's sensational tabloids would indicate that there is a substantial market for information which can neither be considered instructive nor knowledge in any sense of the word other than the act of knowing. If we limit our concept of knowledge to the act of knowing, then medical information, in the broadest sense, may be described as the communication or exchange of meanings, whether they be ideas or facts, related to health or healing. While we may prefer a more selective and discriminating definition of information to reflect the concept of validated knowledge, or that which is beyond the mere act of knowing, the broadest definition of medical information is more useful in studying its development as a progression of forms or formats designed to solve specific problems or meet specific needs. Regardless of how defined, the

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history and development of medical information is a reflection of the history and development of all information.

Our earliest recorded information about man indicates that people have always been concerned about health and medicine. Archeologists, paleopathologists and others have found considerable evidence which shows that primitive man suffered from a wide variety of diseases and developed some interesting, if not altogether effective, methods of healing. We can assume that when early man developed the capability of reasoning, disease was recognized as an intellectual concept but not necessarily as a natural phenomenon. It is more likely that diseases were viewed as supernatural phenomena. Without a scientifically determined base of information, man developed a magical and superstitious framework of assumptions about the world and how it worked.

While most cultures seem to have developed a variety of ways of dealing with disease, some common threads appear to have run through all cultures. Most notably, these included cause and effect observations coupled with ritualistic activities believed to lead to the influencing of human or natural events by an external and impersonal mystic force which was beyond ordinary human experience.

Thus, magic and religion played an important part in the medicine of early man, and the earliest doctors were shamans, witch doctors, and sorcerers. Medicinal cures, learned by trial and error and using indigenous products, such as herbs, plants, bodily fluids, animal parts, etc., were used along with talismen, charms, and spells. These earliest attempts to cure illness gave rise to a body of folk medicine which was passed orally from generation to generation, with each generation undoubtedly adding or subtracting from the base of information as it saw fit or as circumstances and the environment dictated. Whether or not this folk medicine was truly effective in the treatment of disease, it was a part of the overall societal information base and it was believed by the members of each society in which it was generated.

Over time the volume of ideas and beliefs in the societal information base increased to the point that memory alone was not able to contain it reliably. Thus, primitive man was faced with mankind's first problem in information theory: how to represent and record information outside of the human mind and in such a way that it could be retrieved and used.

Unlike many problems of today, this problem did not result, so far as we know, in the appointment of a committee. Nevertheless, primitive man did begin to experiment with the use of symbols to represent ideas. This phenomenon occurred at different times in different places, and numerous ex-

amples have survived to the present, shedding light on the ways in which man sought to represent information. The invention and use of such common symbols as pictures, pictographs, and writing solved the problem of recording information, but man faced other problems concerning the medium on which to record information.

The earliest record of the practice of medicine has been found in the clay tablets bearing cuneiform inscriptions used by Babylonian physicians about 3000 B.C. Much of what has survived from this period came from the great library in Nineveh which was founded by the Assyrian king, Ashurbanipal, who ruled from 668-626 B.C. Ashurbanipal's library was the first in the ancient Near East to select and catalog its materials systematically. It was an extensive library which included works on religion, medicine, astronomy, literature and human, animal and plant behavior. More than 20,000 of the clay tablets collected by Ashurbanipal may be found today in the collection of the British Museum.

Among the next earliest records of medicine are the engravings and paintings discovered in Egyptian tombs. They tell us that, among other things, rudimentary surgery was practiced at least as early as 2500 B.C. Obviously, engravings and paintings on stone were limited in their communications function. The invention of papyrus, however, provided a lightweight, portable medium which enabled people to write down their thoughts, preserve them, carry them about, or send them to others. One of the premier examples of this medium is the Edwin Smith Surgical Papyrus, which is part of the New York Academy of Medicine's collection. This work dates from approximately 1600 B.C., is undoubtedly a copy of a much earlier work, and contains some 22 pages of information relating to the surgical treatment of wounds and other injuries.

Thoughout history man has found or created a number of substances on which to write. Walls of caves were nice but not transportable, carving in stone was expensive and time consuming, wax tended to become soft or melt, clay tablets were not very durable or portable in large numbers, and the aquatic papyrus plant was not found widely throughout the ancient world. However, each of these media were used with some success to convey information. Other media included wood, bamboo, silk, animal skins, linen, leaves, ivory, and cotton, to name but a few.

In the strictest sense, the Egyptian papyri such as the Edwin Smith Papyrus were books. The history of the book has been a distinguished one and far too broad a topic to address in much detail today. As a collection of pages fastened together in some way and containing the written or printed word,

the book has been hailed as the greatest technological revolution or achievement in man's history. While man wrote books on whatever medium was at hand, it was not until the invention of paper in China that people had access to a convenient medium which could be produced in large quantities with relative ease and economy. Although the invention of paper was announced to the Chinese Emperor in 105 A.D., it did not reach Europe until its importation into Saracen Spain in approximately 950 A.D. Even then, the adoption and use of paper spread very slowly through Europe, and it was not used in England until the late 15th century.

By the end of the 14th century, primitive block printing, which originated in China around the sixth century, had spread to Europe. In this form of printing, words or pictures to appear on each page were carved in reverse on a single block of wood, inked and pressed against the surface to be printed. This process was used to produce the earliest known printed works which include a series of Buddhist incantations printed in Japan from 764 to 770 A.D. and the *Diamond Sutra,* a section of the Bhuddist scriptures, printed in China in 868 A.D.[2] The initial use of block printing in Europe was to produce the outlines of initial capital letters which appeared in handwritten manuscripts. Later, wood-block printing was used for pictures and, finally, for whole pages of text. Obviously, carving each individual letter for the text of a whole page from one block of wood was a slow and uneconomical process.

Interestingly enough, the Chinese had invented moveable type some 20 years before the Norman Conquest. However, the nature of the written Chinese language, requiring some 80,000 symbols to create necessary ideograms, precluded a major development of the moveable type concept in China. It was not until about 1450 that moveable type began to be used in Europe. Johannes Gutenberg, a German craftsman and inventor, is generally credited with the development of methods to use metal moveable type in printing. Best known today for his 42-line Bible, he invented a method to cast type precisely and in large quantities, developed a new alloy for type metal, and developed a new printing press based upon those already used for winemaking, papermaking, and bookbinding.

The superiority of moveable type used in conjunction with the printing press resulted in European block printing gradually giving way to typography for printing books. For the first time books could be printed rapidly and in large quantities. It is interesting to note that while it was the use of paper that made printing possible, it was printing that made the use of paper widespread throughout Europe.[3]

As more people became involved in medical studies and more and more medical books were printed and disseminated in the 16th century, it became increasingly difficult for physicians and scholars to keep abreast of the current literature and to select that which was most important. Concern for this problem led to the compiling of medical bibliographies.

The combination of great advances in the field of medicine and changes in medical education in the 17th century created new needs for information. The time required for the production of printed books meant that recent discoveries and the results of experiments were not made available as soon as people wanted them. Of course, personal communications, in the form of letters, were a great source of medical information; however, these obviously did not receive wide dissemination. The increasing pressure for more current information resulted in the concept of the medical congress and the printing of the first scientific periodicals.

The Academy's collection contains a program of the first medical congress held in Rome over a 15-month period, from March 10, 1681 until June 8, 1682.[4] Those of you who may have thought today's 12-hour program a bit overlong can see that our offering is actually quite modest in comparison. Although the medical congress or conference was useful, it was somewhat limited in its effectiveness simply because modes of travel precluded large numbers of people from participating.

The first truly independent scientific periodical published in Europe, *Le Journal de Scavans,* was published in 1665 in Paris. *Le Journal* did not treat medical subjects exclusively, and it was not prepared primarily for the scientist. Rather, it presented abstracts or digests of works on a variety of scientific subjects. It did provide the inspiration, however, for another periodical, the *Philosophical Transactions of the Royal Society,* which did publish original work and new discoveries, primarily of the Society's members. Not only was this work the precursor of modern medical journals as we know them, but also it was the earliest regular periodical publication by a scientific society.

The 18th century and the first half of the 19th century has been called the golden age of individual bibliographers. During this time medical bibliography reached the limits of what one person, working alone, could accomplish in attempts to control the literature. The literature was simply too vast. A number of noble experiments with bibliography laid a new foundation for the future of the field during this time, and one new form for communicating medical information was introduced. The abstract journal, first introduced in 1830, sought to collect the information pertaining to given subjects from

a variety of sources and to permit a reader to survey the main ideas of the literature without reading the originals. Until World War I abstract journals enjoyed a great popularity, and many were published. Brodman has noted that after the war they never quite regained the same level of importance and popularity.[5]

In the late 19th century and 20th centuries a great deal of effort was spent in refining the techniques of medical bibliography. New technologies were brought to bear on gathering and indexing information and on printing bibliographies. The *Index Catalogue* and the *Index Medicus* represent two of the greatest achievements in the history of the development of medical information. Today we take for granted that our major source of medical information, *Index Medicus,* uses standardized indexing terms or subject headings, but this was a major innovation in the field of medical information. Another innovation has been the systematic and comprehensive use of cross-references to assist in locating what is needed.

Two other recent forms of communicating medical information deserve some attention. The separately published, and sometimes unpublished, research report has proved to be a major source of medical information in this century, and is often a source difficult both to identify and to obtain.

The other major source has been the audiovisual or nonprint media. While illustration, usually in the form of anatomical illustration, had been used since at least the ninth century, photographic representations of medical information have had a profound effect ever since the invention of photography in the 1830s. As early as 1863 Oliver Wendell Holmes found photographs of great use in his studies of the human gait. The sequential photographs of human and animal motion made by the British-born photographer Eadweard Muybridge and published in 1878 caused quite a stir in both popular and scientific circles for what they revealed about human anatomy and locomotion.

In recent years there has been a widespread use of 35 mm slides, moving picture film, videotape, videodisks, and other such media to capture and record information which cannot be described or depicted adequately in printed form. Audiotape has also been used, by itself and in conjunction with visual media, to communicate medical information aurally. The relative power and impact of these media are still being evaluated, but their use seems to be increasing, both in medical and patient education.

We cannot, of course, ignore the impact of the computer on medical information and its dissemination. The pioneering work in this field which has been done by the National Library of Medicine and others has had profound

effects already and promises to have more. The online bibliographic citation databases, searchable through standardized terms using the principles of Boolean logic, have created one of the most powerful research tools the world has ever seen. Yet, even this is not enough to satisfy the demand for more and more medical information. We have seen the beginnings of experiments to store and retrieve full texts of scientific articles in machine readable form, the beginnings of online publication of scientific information, the development of knowledge bases and "expert systems" for enhancing our applications of medical knowledge, the advances in the field of artificial intelligence, and the use of optical disks for mass storage of information. We might well ask, "What next?" And I suspect that we will hear some answers to that question in this afternoon's presentations.

I have skimmed rather quickly and somewhat superficially over the various forms of communications which have been used throughout history to convey medical information. I have spoken mostly about information rather than knowledge, and there is a great difference. As a species, we have progressed from a point of having not enough information and not enough knowledge, to a point of having too much information and still not enough knowledge. We cannot absorb all of the medical information available to us. Nor can we begin to synthesize all of it and apply it. We are not even able to determine what, of the body of medical information, is actually valid information or knowledge and what is not.

This state of affairs is due, in part, to the vastness of the medical literature and in part to the difficulty in developing consensus within the medical community on everything from medical education and research methodologies to appropriate therapies and acceptable clinical procedures. Some contend that the vastness of the literature is due to an increase in specialization among researchers, and others contend that the increase in specialization among researchers is largely an attempt to make sense of the literature. I suspect that both of these concepts are partly correct and that other factors play an important part as well.

Our physician manpower experts tell us we are about to develop a physician glut while at the same time less public money seems to be available to support basic research and medical education. Perhaps we will soon see a reduction in the number of people generating medical information, although I doubt it. While there seems to be no limit to the numbers of new medical journals and books produced each year, the economics of publishing have tightened dramatically in the past five years. The effects of this are only beginning to be felt in terms of the reduced numbers of copies of any pub-

lished work which are being produced, and the reduced spending capability of a major market sector—medical libraries.

Whether or not the amount of new medical literature and new medical information continues to expand or begins to decrease, we are still faced with the problem of determining that which is most valid and useful of what we already have and what we will generate. We have made modest attempts to do this in the past, including counting the number of times a given article or journal is cited. We now have the technology to enable us to count the number of times a given article is retrieved through online bibliographic searching. These methods could tell us what the scientific scholarly community perceives as important, and, in a sense, would validate certain pieces of information in the context of current understanding and research interest. I doubt sincerely, however, that such methods, had they been employed some 30 years ago, would have revealed the importance or validity of the research on mobile genetic elements for which Barbara McClintock recently won the Nobel Prize. This example illustrates that the process of validating information should provide for the archival retention and accessibility of that information which is not validated in the context of contemporary knowledge.

We must continue to seek ways to improve our control and use of information. Crawford has demonstrated how the work of Machlup and Porat described and developed a concept of the information society, raising our awareness to its implications.[6] Currently, it is estimated that fully one half of the American work force is engaged in the production or processing of information.[7] From a societal perspective, this vast information base represents a new kind of transactable commodity, the control of which may well become more important than the control of material and energy resources as a means to social and ecomomic power. Inherent in this idea is the need for a well-reasoned and forward-looking national information policy if our society is to continue to dominate world politics and economics.

Even closer to home, however, information policies within institutions where medical information is generated, processed, and used are needed also. Recently Matheson and Cooper have shown us that within our medical institutions we have a wide variety of information resources which are not integrated in such a way as to provide maximum benefit to researchers, educators, students, administrators, and those involved directly in patient care.[8] They suggest ways in which we can begin to integrate our institutional information bases and, perhaps more important, stress the value of local analysis of the economic factors surrounding information as a major institutional resource.

We must begin to ask and develop answers to some very hard questions. Just exactly what is it that we want our medical information systems to do? Do we want citations to literature which might give us an answer to a clinical question, or do we want the answer to the clinical question without having to consult what might or might not be relevant portions of the literature? How is medical information now used and by whom? Are there better ways to use such information? Should levels of complexity of information be designed within a medical information system for use by personnel at varying levels of skill or knowledge? Do we want massive information systems available locally or are we willing to support only smaller local systems which have the capability of communicating with larger systems elsewhere? Who will be involved in the process of validating the information base of medicine, and in what ways will they be involved? What human and financial resources are we willing to commit to developing our information systems? Who will design and implement them? In what ways will our information systems influence public opinions and attitudes or be influenced by them?

And what of the future—when we have answered such questions and when we have integrated our information, evaluated it for its usefulness, validated that which is knowledge and separated this from that which is not knowledge, and developed ways to repackage our knowledge on demand into units which are specially tailored to special needs? What will be the primary communications format for medical information at that time? Will we be able to convene a conference on books and the physician at such a time?

I think we shall still be able to convene such a conference, and not just in an antiquarian context. It seems unlikely to me that the medical book will ever wither away totally and disappear. After all, the book represents an ideal communications format. It is easily portable; it is highly durable; it provides random access; it can be accessed anywhere at any time; its use does not require or consume energy; it is absolutely cost-effective; and it is immensely satisfying to hold and to read.

As to other questions about the future of medical information, perhaps my wisest course of action is to conclude my remarks with another of Osler's aphorisms: "Look wise, say nothing and grunt. Speech was given to conceal thought."[9]

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